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FOREIGN TECHNOLOGY DIVISION

CHRONICLE

VI ALL-UNION CONFERENCE ON NONLINEAR OPTICS

by

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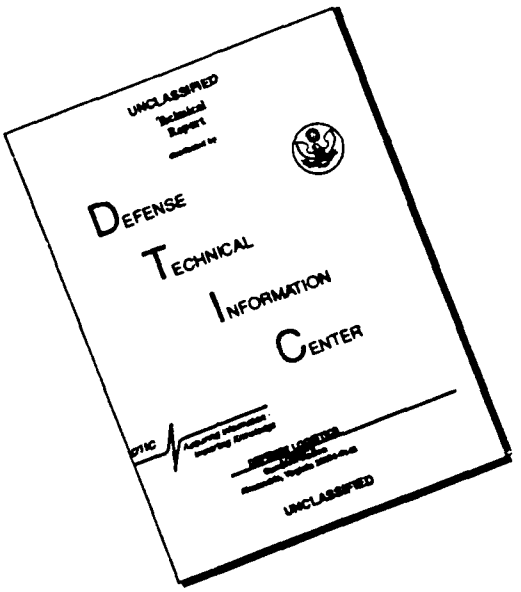

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sec	sec	sch	sech	arc sch	sech^{-1}
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Russian	English
rot	curl
lg	log

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Chronicle/news item.

VI All-Union conference on nonlinear optics.

In period from 29 June through 1 July, 1972 in Minsk took place the VI All-Union conference on nonlinear optics. In the work of conference, besides the Soviet scientists (more than 600 people), took part the representatives of many foreign groups, which actively work in this field of science (40 people of 10 countries).

In accordance with main trends of investigations work of conference passed to 11 sections: interactions of emission with substance; self-stress of light waves; forced scattering; resonance nonlinear effects; nonlinear effects in atoms and molecules; nonlinear processes in crystals; nonlinear optics of semiconductors; nonlinear spectroscopy; optics of supershort pulses; lasers on organic compounds; instruments, based on nonlinear effects.

Entrance report was conducted by R. V. Khokhlov, in which thorough survey/coverage of development of nonlinear optics in recent 1.5 years, which passed after V All-Union conference on nonlinear optics, was given. In the report are especially isolated four sections, which within this time strongly developed and drew attention and efforts of the large number of researchers: nonlinear spectroscopy, nonlinear optics of infrared and ultraviolet wave bands,

nonlinear fiber optics.

One of developing directions of nonlinear optics - investigation of nonlinear processes during resonance excitation of atoms. At the conference were examined the phenomena, which appear with the passage of laser emission through the resonance media: a change in the angular and spectral distribution of emission in the potassium plasma (V. S. Burakov et al.), the phenomenon of the rotation of the axes of the ellipse of polarization in the vapors of rubidium and the generation of harmonics in mixture of vapors of rubidium and xenon (A. M. Bonch-Bruyevich et al.) the dispersion of nonlinear susceptibility in the vapors of potassium (S. A. Akhmanov et al.), parametric interaction of waves (A. A. Afanas'yev et al.). The special features of interaction of the waves of different polarizations in the resonance media of the type of the chaotically oriented linear and circular dipoles, between which is feasible the energy exchange, are studied by P. A. Apanasevich and V. G. Dubovets. The experimental investigation of the self-induced transparency and photon echoing, that appear during interaction of the pulse emission of CO_2 laser with gases BCl_3 and SF_6, is carried out by N. V. Karlov et al.

At conference considerable number of works was devoted to study of mechanisms of phenomenon of self focusing and processes of destruction in different media, and also effect of self focusing on work of optical lasers and generators.

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R. V. Khokhlov et al. reported the results of the experimental observation of self focusing of light in the absorbing medium. Experiments were carried out with the emission of xenon laser, focused in the cell with rhodamine 6Zh.

In scientific schools of N. G. Basov, A. M. Prokhorov, R. V. Khokhlov possibility of using laser emission for initiation of directed chemical reactions is shown. In the recent two years are obtained the first serious results, which served as base for the new scientific direction - laser chemistry. At the conference it was reported about the two-stage photodissociation of molecules by laser emission as the universal method of the realization of selective chemical reactions. In this method the molecule is irradiated by two laser pulses of different frequencies. One emission (exciting) is found in the resonance with the vibrational-rotational transition/junction of molecule, and the second (dissociating) realizes photodissociation of the oscillatory excited molecules. This process is interesting in that it makes it possible to dissociate the molecule of the specific composition in contrast to usual flash-photolysis of gas mixture. Experimentally for these purposes was utilized emission of CO_2 and hydrogen lasers (V. S. Letokhov et al.). The kinetics of processes in the gases is theoretically investigated at the running or erect fronts of the waves of the chemical reactions, initiated and controlled by laser emission. Are discussed the possibilities of using the waves of reactions,

controlled by laser emission in different spectral ranges, for the investigation of the kinetics of chemical chain reactions (V. Ye. Khartsiyev). Is examined the method of the investigation of the dynamics of the photochemical chain reactions, caused by intense beam of light (K. Dari, FRG).

Is discovered phenomenon of self-diffraction of coherent emission, which consists in the fact that supplementary light beams, three-dimensional/space divided from initial, are formed during mutual imposition in substance of two or more coherent waves. Self-diffraction appears on the diffraction grating, formed as a result of the fact that constructed interference pattern three-dimensional/space modulates the optical properties of substance (refractive index and the absorption coefficient). Self-diffraction was observed on the thin layers of the fluid solutions of the absorbing and cleared substances with the use as the sources of light of lasers on the ruby and the glass with neodymium, that work in the modes of the q-switching and free generation. Are discussed questions of the application of self-diffraction in transient holography and optical information processing on real time (A. S. Rubanov et al.). A change in the refractive index of the piezoelectric crystals of lithium columbate under the action of the heterogeneous in the beam section of light is used for obtaining the phase holograms. Recording and playback were conducted during the use of helium-neon and pulsed solid-state lasers (M. S. Soskin et al.).

At rapid tempo is developed nonlinear optics of semiconductors. Spontaneous Raman scattering in the semiconductors has already long ago served as the effective instrument of the study of the properties of acoustic phonons, plasmons, polaritons, etc. of elementary excitations. For each of these spontaneous processes there is a forced analog. Is recently obtained forced Raman scattering in indium antimonide with the transition/junction between the spin sublevels of Landau. At the conference it was reported about obtaining of induced radiation (0.535 μm) on the phosphide of gallium with the transition/junction on the phononless line of the exciton, connected on the isolated/insulated admixture/impurity of nitrogen (S. L. Pyrhkin and I. D. Yaroshetskiy), and on the phosphide of indium (N. A. Ferdmar and Ye. V. Russu).

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Large number of works in field of nonlinear optics of semiconductors is connected with detailed study of effect of structure of zones on coefficient of absorption of number of semiconductor materials. Transmission augmentation and blackout of the single-crystal plates of zinc telluride during the intense laser excitation in the spectral range from 0.528 to 0.61 μm, explained by the strain of the absorption edge, is discovered by V. P. Gribkovskiy. The application of such plates for producing the modulators of light and passive locks for the lasers with the q-switching is possible.

On the other hand, by methods of two-photon spectroscopy it is possible to reveal/detect divergence of zones from parabolicity. By these methods are studied the frequency dependence of polaritons in selenide of cadmium (D. N. Klyshko), exciton states in cuprous oxide (A. I. Bobrysheva), thin effects of the spin polarization of excess carriers in indium antimonide and halcogenides of lead (A. N. Danishevskiy et al.), dual optical and acoustooptical resonances on the excitons (S. A. Moskalenko et al.).

In semiconductor crystal of cadmium selenide is for the first time obtained parametric generation at wavelength 7.86 μm with power of about 5 kW during pumping from laser on fluorite (2.36 μm) with power of 1 MW (A. M. Prokhorov et al.).

By G. B. Abudlayev, by A. M. Prokhorov et al. is obtained and investigated new nonlinear material - gallium selenide. Are grown single crystals to 30 mm in diameter and more than 100 mm by length. A good transparency over a wide range (from 0.65 to 18 μm), the high value of nonlinear susceptibility and the existence of the conditions of phase synchronism in the region from 0.69 to 10.6 μm make gallium arsenide very interesting material for obtaining the summation and difference frequencies. The second harmonic of laser emission on molecules CO, CO_2 and on the crystal of fluorite with dysprosium is experimentally obtained on this material.

With creation and development of powerful/thick laser light

sources arose and at the present time was formed new section of spectroscopy - nonlinear spectroscopy. Classical spectroscopy is linear and rests completely on the theory of interaction with substance of weak flows. The propagation of such flows always can be described by the absorption coefficient, by refractive index and by source function - by parameters, which do not depend on the intensity of the luminous fluxes. In the region of the powerful/thick flows of light these parameters to a high degree depend on the intensity of light. In nonlinear spectroscopy the series of the methods, which ensure the superhigh resolution of the spectra, is developed. They include the methods: the saturating absorption in the gases; the resonance lines, caused by the three-dimensional/space "burn-out" of molecules in the standing light wave; the dual resonance, in which the molecule undergoes the effect of optical and radio-frequency waves; active spectroscopy, in which on the base of a certain nonlinear effect molecular excitation is conducted, after which they are studied with the aid of the supplementary emission; the frequency dependences of nonlinear susceptibilities and other methods.

At conference large number of reports was devoted to examination of interaction of strong applied field with two- and three-level systems. Are in detail examined probabilities and forms of the spectra of induced radiation and absorption, nonlinear phenomena in the gases with the quadratic and cubic nonlinearity, questions of the polarized fluorescence during two-photon interaction and other questions.

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Great interest caused report of S. A. Akhmanov, V. G. Dmitriyev et al., in which were presented principles and some results of experimental application of method of active spectroscopy of Raman scattering. In the experiment on the crystal of calcite the emission of neodymium laser and emission with the retunable frequency from the parametric generator acted. Due to the nonlinearity these two emissions excite in the calcite the phonons, which scatter the second harmonic of the emission of neodymium laser to the Stokes side. Retuning the frequency of parametric generator, it is possible to obtain the form of the spectrum of any line, active in Raman scattering. This method offers new possibilities in spectroscopy, since it makes it possible to reveal very weak lines and to investigate their form.

Another method of nonlinear spectroscopy was presented in report of V. S. Letokhov et al., in which was examined possibility of resonance change of total number of particles at excitation level with frequency transmission of field through center of Doppler widened line of absorption. The narrow resonance of the total number of particles can be observed, for example, in the intensity of fluorescence from the excitation level. This method, called the method of "nonlinear-fluorescent cell", is very promising for nonlinear laser spectroscopy within the Doppler widened transitions/junctions and for frequency fixing of gas lasers.

Dependence of two-photon excitation of green luminescence of crystals of fluorite, activated by rare-earth elements, is investigated with the aid of laser in solutions of organic dyes with scanning of frequency. Are obtained the spectral ducts/contours of the two-photon excitation of the ions of erbium and holmium with the retuning of the frequency of excitation in intervals of 0.744-0.761 and 0.715-0.725 μm respectively (P. A. Apanasevich, R. I. Gintoft et al.). The retunable laser on the neodymium glass (1.[illegible]1 μm) was used for taking the spectral ducts/contours of the fac[illegible]rs of amplification of crystals and glass, activated by trivalent neodymium (V. I. Kravchenko et al.).

Several reports were devoted to questions of evaluation/estimate of possibilities of designing of spectroscopic instrumentations with use of nonlinear effects. On performing of experimental work on the creation of the absorption spectrometer of the near IR range, based on the principle of the conversion of IR emission into the visible region, it is reported in the report of B. N. Antonov et al. In the experiment the emission of wide-band IR source with the emission of argon laser (0.488 μm) in the crystal of lithium columbate mixed. The emission of summation frequency, which lies at the region 0.41 μm, was detected. With a change in the temperature of crystal from 160 to 360°C the region of the spectrum from 2.4 to 3.3 μm consecutively/serially is converted into the visible region. The line of the absorption of ammonia in the region 2.89 μm is recorded with the aid of this spectrometer. By V. V. Arsen'yev et al. is created

pulse fluorometer with the application of picosecond lasers (neodymium and ruby, working in the mode of self-synchronization modes). The time resolution of instrument reaches $5 \cdot 10^{-11}$ s. With its aid the quenching of the fluorescence of chlorophyll is investigated, are taken curves of quenching and the time of the fluorescence of some organic dyes.

Considerable attention at conference was given to methods of generation and amplifying short light pulses, to their propagation in different media. At the present time are already created the pulse generators with a duration of from 0.5 to 2.5 ns with the limited spectral band on the base of yttrium-aluminum garnet with neodymium.

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Are obtained also generation and the amplification of powerful/thick narrow pulses on the base of the forced combination anti-Stokes scattering and straight/direct two-photon processes. Such systems are promising for exciting the controlled plasma by heating by the laser pulses (R. L. Karman et al., USA). It is shown that to the form of the emission impulse of laser with the q-switching (Naymen, USA) strongly affects the introduction inside the resonator of nonlinear element (crystal of zinc sulfide).

Evolution of narrow pulses in amplifying medium during relaxation between sublevels of excitable and ground states of molecules is investigated. This problem is interesting from the point of view of

the generation of picosecond pulses in the lasers on the organic dyes. The propagation of pulses in the amplifier on the molecular gases is studied (R. V. Khokhlov et al.). On the base of the developed theory of super-luminescence in the field of supershort pulse with the frequency modulation in the dispersive medium is carried out the analysis of different modes of amplification, which appear in the experiments with the picosecond pulses during three- and four-photon interactions (A. P. Sukhorukov et al.). Are studied the properties of the rarefied gases, excited by the pulses of high-energy electron beams (~1.2 MeV). Is obtained the emission of vacuum ultraviolet from the atomic and molecular structures (S. K. Rodes, USA).

Process of decomposition of surface of nonlinear crystals of type of lithium columbate under effect of laser emission was investigated. The durability of the surface of the materials is considerably (5-10 times) lower than durability of the surface of glass being investigated and does not depend on the quality of the surface treatment. It is established that the durability of lithium columbate increases with an increase in the temperature (G. M. Zverev et al.).

Several works were devoted to investigation of phenomenon of optical breakdown in gases. The mechanism of the formation of breakdown in argon and nitrogen under the influence of the focused laser emission with the wavelength of 0.35 μm and durations of 30-50 ps is experimentally investigated. It is established that for both the gases in the range 0.5-6 atm. being investigated threshold

intensity weakly depends on pressure, which indicates the multiphoton mechanism of the ionization of the atoms (molecules) of gas (A. M. Prokhorov et al.). The frequency dependence of the threshold of optical breakdown in air with the use of the stabilized harmonic generator on the neodymium glass is investigated. Is experimentally studied the mechanism of the directed electrical breakdown in air, ionized by the collimated ultraviolet radiation (L. V. Norinskiy et al.). Are investigated the possible mechanisms of the threshold visible and ultraviolet glow of ammonia, which appears under the effect of powerful pulsed laser on CO_2 at the power lower than the threshold intensity of optical breakdown (V. S. Letokhov et al.).

Considerable attention at conference was given to optics of supershort pulses, to their formation and to measurement. Pulses with a duration of up to 0.4 ps are already obtained.

Direct observation of their time structure is most ideal method of characteristic measurement of supershort pulses. N. G. Basov et al. for these purposes used image converter tube with high-speed scanning/sweep, which has the time resolution of order ps in the interval of observation with a duration of up to several ten ns. The laser on the neodymium glass, which works in the mode of self-synchronization of modes, is investigated. R. L. Karman (USA) reported about the application for the same purposes of instrument with time resolution in 5 ps.

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With the aid of sensitive electro-optical moving-image camera with resolution 250 ps were observed consecutive stages of development in time (during 1.5 μs) of generation of narrow pulses in laser on neodymium glass, which works in mode of self-synchronization of modes (P. G. Kryukov et al.). The same authors showed that the propagation of the ultrashort pulse through the two-component medium results in reduction of duration and decrease of the number of supplementary satellites of main impulse. The conclusion about the possibility of applying the stable two-component medium as the method of the formation of single ultrashort pulses is made on this foundation.

Great interest caused report of K. P. Burneykya et al. about photo-tropic tape/film locks, suitable for modulation of quality and synchronization of modes of ruby and neodymium lasers, and also for parametric generators of light (PGS) as nonlinear filters. These locks make it possible to obtain the more stable radiation characteristics of solid-state lasers in comparison with the liquid seals, and filters in PGS to a considerable degree narrow generation pulse.

Investigations in field of generation of solutions of complicated organic compounds were recently directed toward creation of powerful/thick laser radiation sources with smooth retuning of oscillation frequency virtually in entire optical region of the spectrum, to explanation of mechanism of work and to development of

methods of improvement in characteristics of lasers of this type. In the USSR the greatest successes in this direction are achieved by B. I. Stepanov's school.

All this found bright reflection at conference. In particular, were discussed spectral-time characteristics of generation during the laser and electron-tube pumping (N. A. Borisevich et al.), the kinetics of the spectrum of generation under the varied conditions for excitation (groups of B. S. Neporent and A. N. Rubinov), generation in the circular dispersive resonator (V. I. Kravchenko et al.), the special feature of generation during the pumping by picosecond pulses and by laser emission on nitrogen, and also questions of the photo-stability of dyes and effect of extinguishers on the characteristics of generation. Important practical value have the results of the retuning of oscillation frequency in the region 0.235-0.385 μm by the transformation of emitting the liquid lasers by the methods of nonlinear optics (B. V. Bokut' et al.).

Retunable lasers on organic dyes are promising for application in nonlinear optics, spectroscopy, photochemistry, atmospheric investigations. Unfortunately, at the conference virtually there were no reports on their use in these and other fields of science.

Frequency conversion by methods of nonlinear optics is utilized for obtaining coherent emission on new regions of the spectrum, for creation of sensitive low-noise detectors of IR range and converters

of IR image into visible.

At conference to these questions was given considerable attention. The series of works was dedicated to the improvement of the methods of frequency multiplication on different crystals. Results on the generation of the fifth harmonic of the neodymium laser, which works in the mode of the self-synchronization of modes, are reported. Coherent emission of the power of 200 kW at the wavelength 0.212 μm is obtained as a result of synchroncus four-frequency interaction in the calcite at room temperature (S. M. Santiyel et al.). Is obtained the retunable emission in the distant UV region (in the region 0.174 μm) on the base of the addition of the frequencies of the fundamental emission with the wide spectrum of pumping. This source of ultraviolet radiation can be used in the holography (G. V. Krivoshchekov et al.).

Amplifier of spectral brightness of second harmonic during heterochromatic pumping is created. The excitation of the second harmonic was experimentally realized by wide-band (60 Å) weakly diverging emission of neodymium laser in different nonlinear crystals.

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The 8-10—fold amplification of the spectral brightness of the second harmonic of the central frequency of pumping due to the addition of lateral spectral components equidistant in the frequency is recorded. Is realized the smooth retuning of the wavelength of harmonic in the

limits of the width of the spectrum of the exciting emission (V. D. Volosov).

In report of Yu. M. Ilinskiy and V. M. Petnikova are examined fundamental sources of noise in receivers of IR emission with frequency conversion upward. The results of investigations are used in the problem of the detection of weak signal when ambient noises and spontaneous noise of converter are present.

In series/row of works further development underwent theory of parametric converters and generators of light (S. A. Akhmanov et al.).

Method of mixing of frequencies gives possibility of transformation of IR image into visible. E. S. Voronin's group investigated transformation in the crystal of proustite during perpendicular interaction of beams. Are carried out experiments with obtaining of difference frequency for CO_2 and helium-neon of lasers and summation frequency for CO_2 and ruby of lasers, the band of the converted frequencies and angular characteristics is measured (width of the angle of synchronism on the signal and the pumping). The developed diagram can be used for the transformation of IR image into visible in the narrow frequency band.

On base of diagram of critical "vector synchronism" proposed by authors is examined method of transformation of wide (to several

thousand angstroms) IR spectra into visible range. For the simultaneous conversion of entire IR spectrum into visible it suffices in this diagram to focus one of two emissions (IR or pumping). The spectral interval of transformation is determined by the retuning curve of synchronism and by the degree of focusing. With the aid of the crystal of lithium iodate at the angle of focusing of 40° IR emission throughout the entire band of the transparency of crystal can be transferred into visible range. For the proustite the corresponding angle of focusing composes 60°. Method is suitable for the transformation of the IR spectra of the high-speed processes. Is carried out experiment on the conversion into the visible region of the radiation spectrum of laser on the glass with neodymium (width of spectrum 100 Å) and the spectrum of vapors of potassium in the band from 3.66 to 2.7 μm for one flash/burst of laser (G. V. Krivoshchekov, S. I. Marennikov et al.).

In other experiment for transformation of IR emission into visible throughout entire band of crystal argon laser with power of 0.5 W, which worked in continuous mode with wavelength of 0.488 μm, was utilized. As the source of the converted wide-band emission served globar (A. N. Orayevskiy, F. S. Fatszullov et al.). Nonlinear frequency converter on the crystal of lithium columbate is used for studying the IR spectrum of the Sun in the region of wavelengths 3-5.4 μm. As the source of pumping is used the argon CW laser, which works at the wavelength 0.5145 μm (M. I. Divlikeyev).

Reports and lively discussions at conference testify about appearance of theoretical works of generalizing character and raising scientific-technical level of experimental works in all main trends of nonlinear optics.

As a whole conference took place organizationally and fruitfully. It, undoubtedly, contributed to the development/detection of the promising trends of further investigations in the region of nonlinear optics and ways of the practical use of its achievements.

M. F. Bukhenskiy.

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